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THE EFFECT OF ADDITIVES ON ALKALI RESISTANCE OF CERAMIC MATERIALS

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The effect of refractory chamotte, granite screenings, and dolomite additives on alkali resistance and other properties of ceramics materials synthesized on the basis of a high-melting clay are considered. The regularities of the variations in the properties of fired samples depending on the ratio RO/R_2O in the initial mixture are established.

The properties of ceramic materials, in particular, alkali resistance can be controlled by introducing additives containing RO and R_2O to ceramic mixtures. The joint introduction of these additives contributes to increasing heat resistance and mechanical strength and also intensifies the sintering process [1].

The resistance of ceramic materials to aggressive media, including alkalis, is determined by their phase composition and microstructure. In the reaction between a material and an alkali, the solubility of oxides making part of the structure of the crystalline and vitreous phases decreases in the following order: $SiO_2 \rightarrow Al_2O_3 \rightarrow MgO \rightarrow CaO \rightarrow Fe_2O_3$. It is established that the dissolution of quartz occurs as a consequence of the destruction of SiO_2 crystalline lattice, redistribution of chemical bonds, and diffusion of silicon and oxygen ions. Furthermore, alkali resistance to a great extent depends on the heat generated by the formation of oxides that are part of ceramic materials.

The studies performed in the recent years mostly concentrated on the development of acid-resistant ceramic compositions. However, there is also a demand for alkali-resistant materials in various sectors of industry.

The present study investigated a high-melting clay, whose deposit is situated in Belarus. A specific feature of the chemical composition of this clay is the low content of RO (3%) and R_2O (3%). However, owing to the presence of finely disperse iron oxide (up to 7%), a high degree of sintering is observed at the heat treatment temperature 1050 – 1100°C. In this case iron oxide, which is integrated in the crystalline structure of the kaolinite-montmorillonite layers of clay, acts as a flux.

This particular high-melting clay is moderately plastic and sensitive to drying. With the total content ($Al_2O_3 + TiO_2$) equal to 16 – 19%, it is classified as semi-acid high-melting clay.

To decrease the shrinkage and increase the resistance of the fired material to chemical reactants, in particular to 20% NaOH, refractory waste (broke chamotte articles) was added to the mixture. The properties of the fired material also depend on the granulometric composition of the chamotte. Table 1 indicates the content of various fractions of chamotte introduced to the ceramic mixture composition.

The samples were made by plastic molding. The molded samples were dried and fired at a temperature exceeding 900°C.

The performed studies demonstrated that as the heat-treatment temperature increases, the overall shrinkage of the samples of all mixtures grows to 10% (mixture 3). The minimum shrinkage (6.8%) is registered in the sample of mixture 1 containing the coarsest fraction. The introduction of finer fractions makes it possible to lower the water absorption of the samples (to 10%). The alkali resistance of all samples varies insignificantly (68 – 70%).

The phase composition of the samples is represented by the vitreous and the crystalline phases, as well as α-quartz, mullite, and anorthite.

The introduction of refractory waste to the initial ceramic mixture did not have a perceptible effect on alkali resistance.

TABLE 1

Mixture	Fraction content, %, of size, mm				
	> 3	3 – 1	1 – 0.5	0.5 – 0.08	< 0.08
1	10	40	–	50	–
2	–	25	25	25	25
3	–	–	25	25	50
4	–	–	–	25	75

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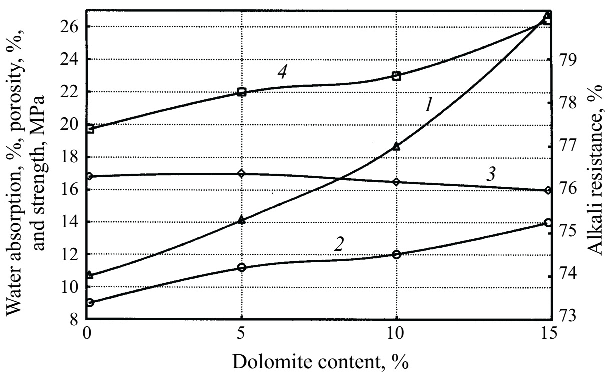

Fig. 1. Physicochemical properties versus the amount of dolomite in ceramic mixture composition: *1*) water absorption; *2*) porosity; *3*) strength; *4*) alkali resistance.

To improve the physicochemical properties, granite screenings, which are a side fraction of sieve concentration, and dolomite were added to ceramic mixtures. These additives contain substantial quantities of RO and R_2O, which makes it possible to intensify the process of sintering in the samples.

It is known from [1] that sintering, mechanical strength, chemical resistance, and other properties depend on the chemical composition of the initial components. The vitreous phase emerging as the consequence of heat treatment not only accelerates the sintering process, but also affects the alkali resistance of the synthesized materials. The introduction of the specified additives modifies the ratios RO/RO_2 and $RO/(\Sigma R_2O + RO + Fe_2O_3)$. On introducing granite screenings (above 100%) to the mixture, the RO/R_2O ratio changes from 1.0 to 1.3.

Due to the increased quantity of the vitreous phase, which judging from the chemical composition is represented by the iron-alkali-silicate melt, the alkali resistance and other properties are improved.

The phase composition of the samples is represented by the same crystalline phases as that of samples of the initial composition. However, the height of the α-quartz peaks observed on the x-ray pattern of mixture 3 is significantly lower than that in the initial mixture sample, which is evidence of a partial transition of α-quartz into the melt. Dolomite as well has a positive effect on alkali resistance. However, when dolomite in introduced into the mixture, the porosity and water absorption of the fired material grow, and its mechanical strength decreases.

The modification in the physicotechnical properties on introducing dolomite to mixtures is reflected in Fig. 1. It can be seen that water absorption and porosity grow as the quantity of dolomite increases. The alkali resistance varies insignificantly (by 3 – 4%) compared to the initial composition, and the mechanical strength decreases.

The study of the phase composition of the samples demonstrated that the main crystalline phase is α-quartz, but mullite and anorthite traces are present as well. It should be noted that on introducing dolomite, the height of α-quartz peaks becomes somewhat shorter. Apparently, part of the quartz is transformed into the melt. A similar situation is observed with respect to anorthite. According to the x-ray phase analysis data, the amount of this phase in the initial composition is significantly higher than in the mixtures containing dolomite.

Of the two investigated additives (granite screenings and dolomite) granite screenings are more suitable for the synthesis of alkali-resistant ceramic materials. When this additive is used in the ceramic mixture compositions, the total quantity of fluxes ($\Sigma R_2O + RO + Fe_2O_3$) grows to 15%, and the ratio RO/R_2O, which is one of the sintering criteria, decreases to 1.1 – 1.3.

Thanks to the introduction of granite screenings into the ceramic mixture and the formation of the alkali-silicate melt, the main physicotechnical properties and the alkali resistance of the synthesized samples are improved.

REFERENCES

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